# Studies on southern Australian abalone (genus *Haliotis*) XV. Fecundity of *H. laevigata*

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## ABSTRACT

Fecundity and length-weight relations were determined for six populations of the greenlip abalone *Haliotis laevigata* on the coast of Eyre Peninsula. The relation between length and fecundity was non-linear with power coefficients of length ranging from 3.7 to 7.2 for different sites. The between-site variation in fecundity is attributed to differences in food supply, water movement and habitat, although genetic effects cannot be excluded. Length-weight relations varied little between sites, and power coefficients of length ranged from 2.8 to 3.2.

## INTRODUCTION

The fecundity of abalone is a life history trait that is important for modelling exploited stocks (Sluczanowski 1984) and for artificial spawning and mariculture. The greenlip abalone *Haliotis laevigata* Donovan is the basis of an important fishery in South Australia. Modern management seeks to identify distinct stocks and manage these in accordance with egg-per-recruit models that allow the setting of minimum sizes at capture (Sluczanowski 1984). Such models require information on fecundity. The purpose of this study was to measure the variation in fecundity of this species of abalone on the southern, central and northern parts of the west coast of Eyre Peninsula, where the principal fishery is based (Fig. 1).

## MATERIALS AND METHODS

*H. laevigata* spawns synchronously from October to March at West Island (Shepherd & Laws 1974) and during December on southern Eyre Peninsula (unpublished data). Samples were collected at six sites in September 1987 before the commencement of spawning when ova are large and rounded. Samples were taken over the full available size range of sexually mature individuals.

Shell length was recorded for each female and the ovary and visceral mass excised and preserved in 10% formalin and sea water. After separation from the viscera, each ovary was weighed. Subsamples of 1-4mg were taken from its anterior, middle and posterior parts and weighed to the nearest 0.1mg. The number of ova in each subsample was then counted on a grid under a low power binocular microscope. The mean egg weight was calculated and, by simple proportion, fecundity (the number of eggs per individual) was estimated.

Subsequently, in further sampling at each site in December 1987, shell length and total weight of samples of *H. laevigata* were recorded in order to calculate the relation between length and total weight.
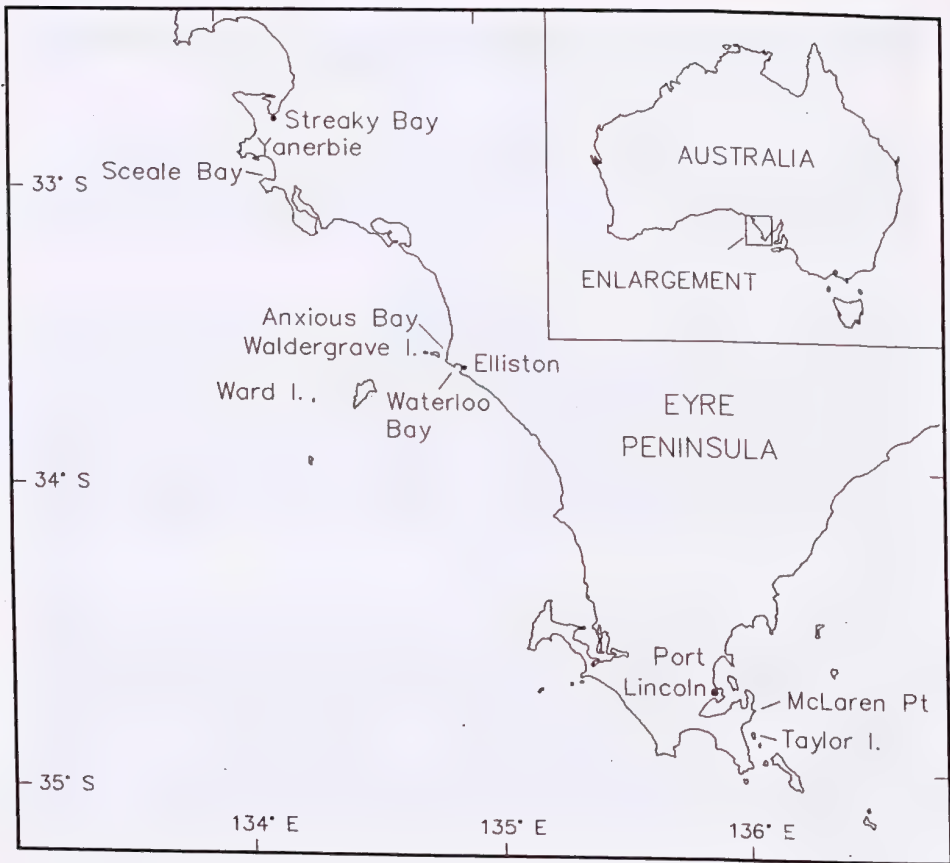
**Figure 1.**   Map of South Australia showing six study sites on Eyre Peninsula.

Linear regressions of log fecundity (number of eggs) on log length were fitted to the data sets. Analysis of covariance (ANCOVA) was performed to compare fecundity between different populations. An assumption of this analysis is the homogeneity of residual variances (Snedecor & Cochran 1980). The Waterloo Bay data did not meet this assumption because the range of x-values was much less than those with which a comparison was sought, so this set was excluded from the comparisons.

## RESULTS

Plots of the number of eggs vs. length for the six sites are shown in Fig. 2 and the fitted log-log regression equations are shown in Fig. 3. Constants of the regression equations are given in Table 1. Analysis of covariance of the regressions for each population (except Waterloo Bay) showed that the fecundity relationships differed significantly between populations (d.f. 4, 65; F=3.09 P<0.05). SNK multiple range tests showed that the two populations with the extreme slopes, Anxious Bay and Sceale Bay, differed significantly (P<0.05) from all others; no other differences

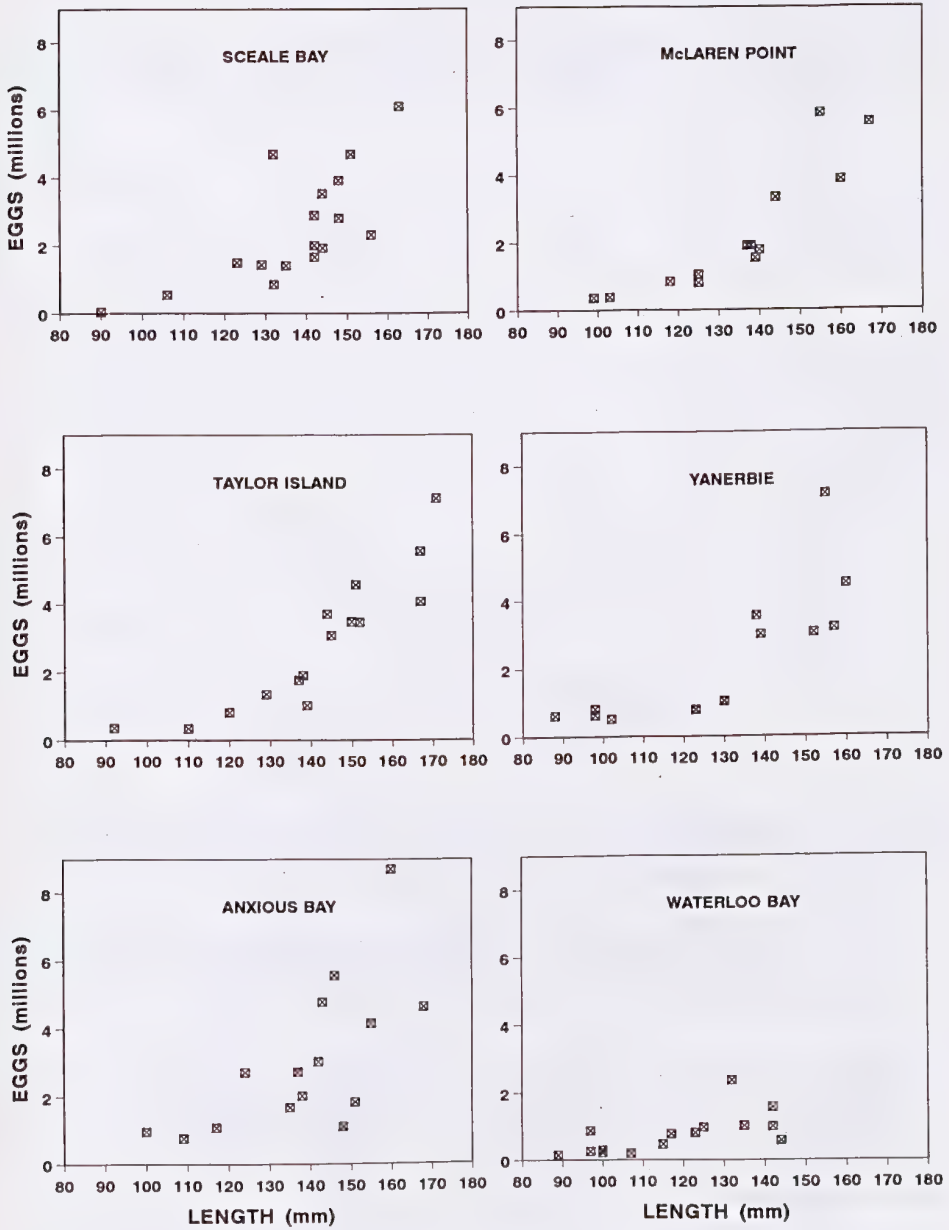**Figure 2.** Plots of fecundity (number of eggs in millions) against length for *Haliotis laevigata* at 6 sites.

were significant. We also fitted linear regression models to the data but in no case did they provide better fits.
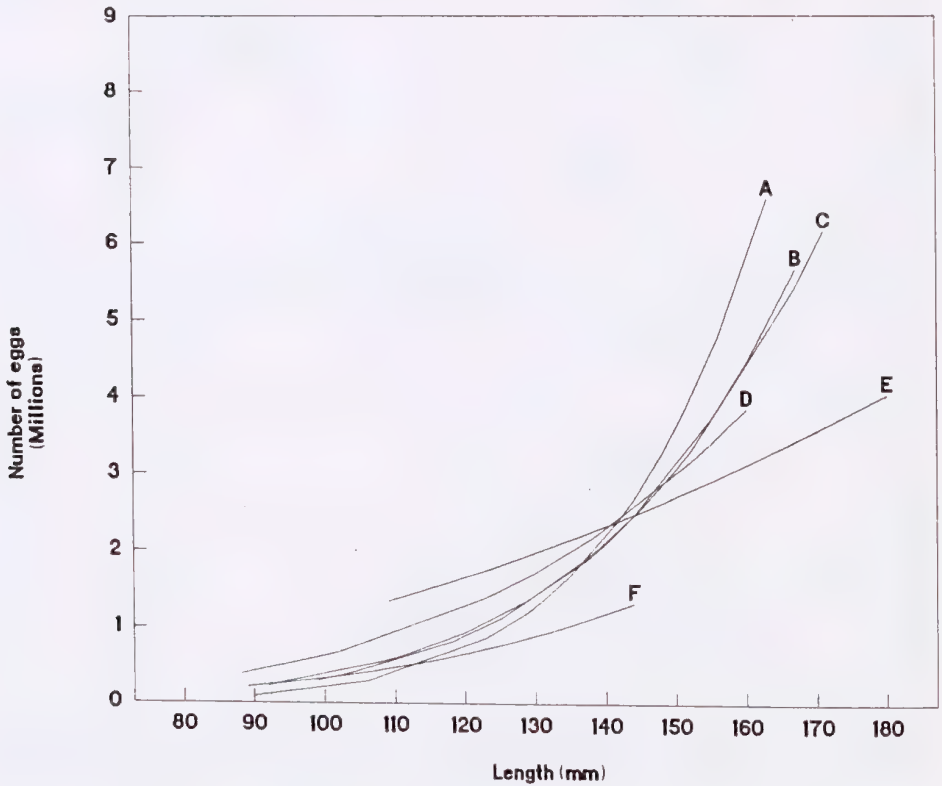


**Figure 3.**    Regression lines showing the relation between fecundity (number of eggs) and length for *Haliotis laevigata* at 6 sites. A = Sceale Bay; B = McLaren Point; C = Taylor I.; D = Yanerbie; E =Anxious Bay; F = Waterloo Bay.

**Table 1.**    Constants of regression equations relating fecundity (F) in millions of eggs and length (L) in mm for *H. laevigata* at various sites. Equations are of the form $F = aL^b$. N is the sample size. Sites are ordered latitudinally from north to south.

| Site | N | a | b±s.e. | $R^2$ |
|------|---|---|--------|-------|
| Sceale Bay (A) | 17 | $6.19 \times 10^{-10}$ | 7.24±0.91 | 0.81 |
| Yanerbie (D) | 14 | $1.11 \times 10^{-2}$ | 3.87±0.65 | 0.75 |
| Anxious Bay (E) | 15 | $2.94 \times 10^{-2}$ | 3.70±0.93 | 0.55 |
| Waterloo Bay (F) | 15 | $6.40 \times 10^{-3}$ | 3.85±0.91 | 0.58 |
| Taylor I. (C) | 15 | $7.55 \times 10^{-6}$ | 5.33±0.54 | 0.88 |
| McLaren Point (B) | 14 | $1.93 \times 10^{-6}$ | 5.61±0.42 | 0.94 |

   The results of linear regressions of log total weight on log length are given in Table 2 and shown in Fig. 4. High coefficients of determination indicate highly significant goodness of fit of linear regression models to the data. Analysis of

covariance showed significant differences between populations ($F = 17.9$; $P<0.05$). However, we do not present further analyses of differences between populations because the samples were taken from the various sites over a period of a month (see Table 2) during the peak of spawning season, when changes in the length-weight relation are expected within a population as gametes are released (McShane *et al.* 1988).
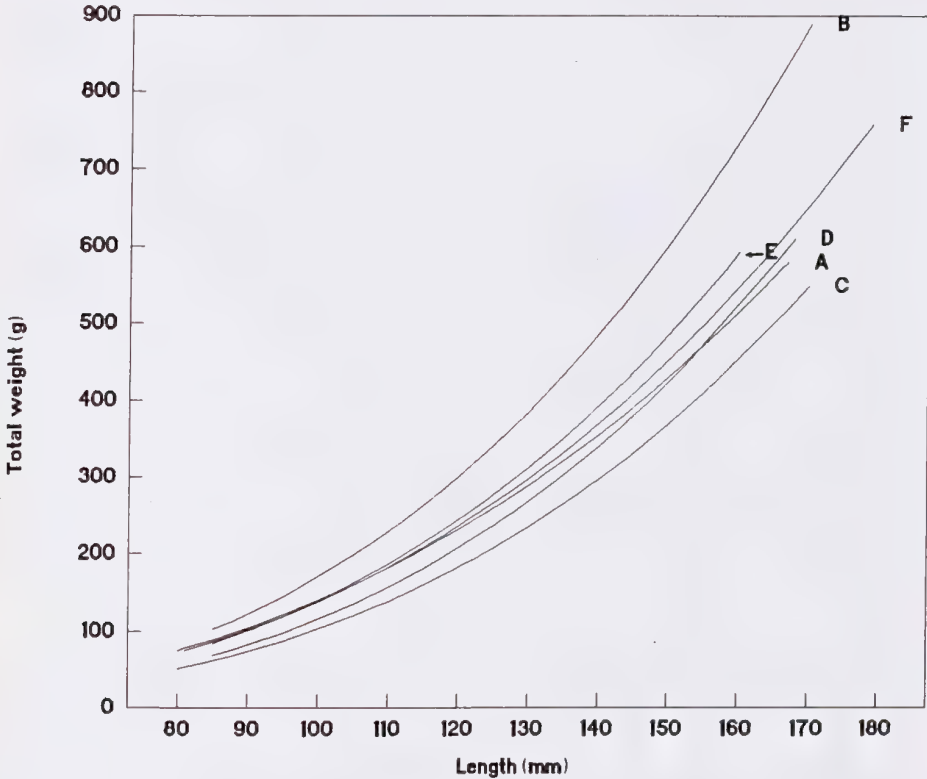


**Figure 4.**   Regressions of length vs total weight for 6 population samples of *Haliotis laevigata*. See Fig. 3 for key to sites.

**Table 2.**   Constants of regression equations relating length (L) in mm and total weight (TW) in g for *H. laevigata* at various sites. Equations are of the form $TW = aL^b$. N is the sample size. Date is the date of collection. Sites are ordered latitudinally from north to south.

| Site | Date | N | a($\times 10^{-5}$) | b±s.e. | R² |
|------|------|---|---------|--------|-----|
| Sceale Bay (A) | 30/12/87 | 59 | 12 | 3.00±0.03 | 0.99 |
| Yanerbie (D) | 4/12/87 | 53 | 4.6 | 3.20±0.08 | 0.97 |
| Anxious Bay (E) | 15/12/87 | 46 | 10 | 3.07±0.07 | 0.98 |
| Waterloo Bay (F) | 14/12/87 | 57 | 20 | 2.92±0.06 | 0.98 |
| Taylor I. (C) | 10/12/87 | 45 | 4.7 | 3.16±0.06 | 0.98 |
| McLaren Point (B) | 10/12/87 | 47 | 5.8 | 3.12±0.05 | 0.99 |

## DISCUSSION

In these populations the relation between fecundity and length is non-linear with power coefficients ranging from 3.7 to over 7 (Table 1). A power of 3 implies that fecundity would have a linear relation with weight and for 3 of the 6 populations the power and its 95% confidence interval includes 3. Fecundity of the remaining populations is highly non-linear with length and therefore also non-linear with weight. Ault (1985) reviewed the fecundity of abalone and noted that a linear relation with weight is found for many species. This is expected because proliferation of oocytes, strictly a surface phenomenon, should be related to gonad volume. However, if the germinal epithelium becomes highly convoluted then a significant increase in fecundity becomes possible, giving rise to non-linearity.

The fecundity of abalone is known to vary between individuals, between populations and even between years (Tutschulte & Connell 1981, Ault 1985, McShane *et al.* 1986, Shepherd 1987) due to differences in food availability, and Shepherd (1987) showed that abalone transplanted to sites with more or less food showed corresponding increases or decreases in fecundity. Yanerbie is the only site of the six known to have stunted abalone presumed due to lack of algal food (Shepherd *et al.* 1992); this would explain the low fecundity there. The low fecundity at Waterloo Bay could have simply been an artifact of the absence of larger individuals in the sample. However, Shepherd (1987) examined a much larger sample over a greater size range in a different year, and found similar low fecundity. He speculated that there may have been a genetic basis for this due to evolved differences in energy allocation strategies. This explanation would also apply to the geographically close Anxious Bay population. The low fecundity at these last two sites is otherwise difficult to explain in terms of food abundance since the growth rates at these sites are relatively high. Transplant experiments are needed to test these ideas.

The relationship between length and total weight also shows significant variation among populations. This may be due to differences in the growth rate between sites or may simply reflect the expected decline in weight relative to length due to loss of gametes during spawning. McShane *et al.* (1988) showed that seasonal and inter-population differences occur in the morphometric relations of *H. rubra*. They attributed the differences to variation in growth patterns between populations; these in turn were probably due to differences in food availability. *H. laevigata* feeds mainly on drift algae, whose availability depends on water movement and frequency of storms (Shepherd 1973). Thus between-site habitat differences and water movement variability must play an important role in morphometric and fecundity differences between populations of this abalone species.

## ACKNOWLEDGEMENTS

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